

A CASE STUDY OF REVERSE ENGINEERING INTEGRATED IN AN ANCIENT INDIAN ALCHEMICAL ALLOYING W. S. R TO AU-CU-ZN ALLOY USING PART- WHOLE SCHEMA

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ABSTRACT

Reverse engineering has prodigious applications and is the prime cause of today's several engineering marvels. Even though its origins are from our childhood toy dissection, it encouraged several innovators like Claudius Galenus (AD 129 – Ca 200), Leonardo da Vinci (AD 1452 – 1519) etc in discovering the innate fundamental principles and enable a device / substance / material / assembly through a organized analysis of its part whole schemata and explore its functions. Its back bone is deductive reasoning and its key tool is dismemberment of parts that make the whole through a unique structure. Present work aims at unfolding materials and methods of copper – gold-zinc alloy, synthesized in Indian alchemical procedures through the concepts of reverse engineering with part whole schemata. However, modern characterization tools like SEM, TGA and Dynamic analysis were also involved in discovering these ancient synthesis root patterns.

KEYWORDS: Indian Alchemy, Reverse Engineering, Gold Copper Alloys & Copper Alloys

Received: Nov 18, 2017; **Accepted:** Dec 07, 2017; **Published:** Jan 05, 2018; **Paper Id.:** IJMPERDFEB201824

INTRODUCTION

Reverse engineering is a Experimental learning model (ELM) composed of concrete experience, observation with reflection, formulation and testing of concepts as per D. A. KOLB (1939) [1]. Reverse engineering according to cognitive viewpoint is a deduction / backward reasoning model where the person who reverse engineers looks at what is there to see and drives on conclusion through inquiry. For this essential questions or higher order thinking skills help at a great extent [1]. Re designing a product/ process purposefully to amplify and enhance its functionalities and blend remarkable life bestowing features is known as reverse engineering [2,3]. The entire process sums up into dissection and integration [2 – 7]. Few researchers also claim that its origins ever existing in every ancient tradition. One such element is the part whole schemata [8,9] which is key to the dissection principle of reverse engineering. Such inspirational dissected drawings of biological entities can be seen in Leonardo da Vinci sketches [1]. Vedic maths sutras [10] and TRIZ principles also emphasize significance of dissecting parts from a structure to understand the whole [11]. Part whole relationships in all realms are very vital and ample research has been undergoing on its deep core concepts [8].

Indian alchemy has its legacy since pre historic period that synthesized several metallic drugs and formulations providing health benefits even today. The other side of it is transmutation, which has challenged

humanity every time and the other is metallurgy, formulating different alloys [12-21]. Gold, silver, copper, zinc, tin lead and mercury are the fundamental metals through which several alloys were formulated. Even minerals and inorganic materials were alloyed those days as a process of theurapathic remedies [17]. Ancient cultures of India Egypt and others believed in wearing of metallic ornaments as they can ease pains in joints and colic. Such note worthy metals are gold, copper and its alloys [22-24]. This paper attempts in reverse engineering the ancient

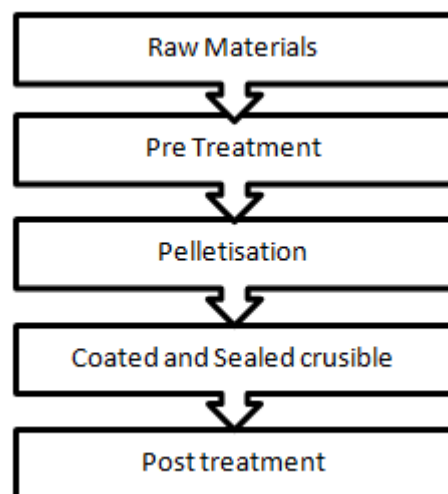


Figure 1: Depicts Functional Breakdown of Whole Process of Ancient Alloying

Cu-Au-zn alloy through the same very ancient roots by dissecting its internal innate processes and parts by keeping in mind the significance of part whole relations at each level of its synthesis.

REVESE ENGINEERING OF CU – AU – ZN ALLOY (MATERIALS AND METHODS)

The part whole schema is undoubtedly the back bone of any engineering and technology in appraising the inner workings of a process / object / system. This in specific plays a even more vital role in applications pertaining to reverse engineering. A whole is a structure made of parts that go hand in hand as a individual system. Scott. D. Findlay et al. proposed a model that consists of tags, organizers, attachers, communicators as major building blocks of a system that aid in sustaining the operation of a structure and relationship between parts. Extractive metallurgy plays a crucial role in Indian Alchemy especially after the ancients realized that metals and minerals affect human health remarkably. Alloying is a part of extractive metallurgy (Satvapathana) where the other two important aspects of Indian Alchemy are incineration and conversion of metallic chemicals by distillation, sublimation etc. The typical process of alloying in Indian Alchemy is shown in figure 1. The following table1 shows the complex organizers and communicators involved in the process of alloying.

All the materials involved in the process are commercially pure grade and acquired from local market. As mentioned above pretreatment of metals viz. gold, copper, zinc and copper extracted through copper sulphate are taken in equal quantities in a crucible coated with a mixture as mentioned in alchemical texts [17-21]. The molten alloy was further characterized using Scanning Electron Microscopy (SEM) which is a method for high resolution surface imaging. This was to exploit the surface topographies of the synthesized alloy. The SEM make is JEOL Model JSM - 6390LV with resolution of 3-15 nm and magnification of 5x to 300,000 x (both in low and high volume modes). For dynamic characterization of

the alloy DEWSOFT X2 data acquisition software with accelerometer and impact hammer having channel setup box are involved. The coating of the crucible devoid of the raw materials was undergone into thermo gravimetric analysis and The TGA system make is Perken Lme, USAA model, Dimond DTG/DTA temperature range RT 15000C @ 100 per min. It is a differential type furnace with air, inert gas as atmosphere having 10 to 2 torr vacuum. The initial sample weights of both specimens with and without the drug are 25 mg and 24 mg respectively. The mechanical characterization of the alloy for tensile, shear and hardness studies was done on INSTRON 3367 50KN capacity, shear load Tensometer and Rockwell hardness tester model VA6-I.

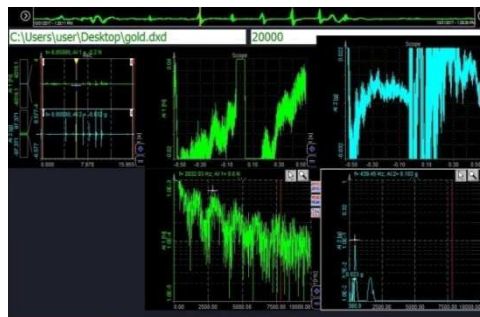


Figure 2: Shows Alloying in Ancient Furnace Figure 3: Frequency Response of the Alloy Strip

Table 1: Represents the Functional Break Down of Pre or Post Treatment Procedures that Act as Organizers / Communicators

Primary Function	Secondary Function	Organizers/communicators
Alloying of two or more minerals and metals	Disrupt the internal structure of the metal	Heating and quenching in Oil of Sesamum Indicum
	Disrupt the compression tension Equilibrium	
	Increase the metal Brittleness	
	Let the oil organic ingredients enter the cracks	Heating and quenching in Buttermilk
	Remove previous unctuous impurities and soften the metal structure	
	Caustic embrittlement & season cracking ,worming it further	Heating and quenching in Cows urine
	Cause Bio-beneficiation of toxic components	Heating and quenching in Fermented gruel
	Reduce its toxicity and weight and increase hydroxide presence	Specific Purifications involving cows Urine
	Remove acid and alkaline soluble Impurities	
	Micro Purification	Tirturation
	Impart organic qualities	
	Increase Fineness	Incineration
	Reduce Particle size	
	Reduce alkalinity	Boiling / Fomentation
	Prolong the molten state of metals for successful alloying	Pelletisation with specified herbs
	Remove external impurities	Soaking
	Accelerate internal dynamics of the atoms	Involving sulphur
	Balance surplus energies with Deficient ones	Involving mercury

RESULTS AND DISCUSSIONS

Pre-treatment of raw materials in any sort of usage in extractive metallurgy is considered to be most crucial part in Indian alchemical. It is known as “Samskara” and it was believed by the ancient Indians that this process transmutes the latent attributes of a substance which leads in summation of new ones. This belief can also be seen in westren alchemical systems especially of Geber who was known to be the pioneer alchemist. Various modes of such treatments are mentioned in Indian alchemical texts such as Svedana (Boiling), Mandhana (churning), Mardana (grinding), Bhavana (impregnation) etc. Each treatment is a unique procedure for the specified raw material. The scanning electron microscopic image of

copper extracted using copper sulphate is shown in figure 4 and thermogravimetric analysis of the aforementioned coating involving honey, clarified butter, sulphur etc is shown in the figure 6. The degradation occurs in more than eight stages with initial degradation between 100 – 112 °C with evaporation of water or moisture content before this cutoff. 50% weight loss of the coating occurred at 110°C and 75% at 1010°C. The final decomposition temperature happened appx at 1200°C with a 11% of residual char content. The critical inflection points are shown in the corresponding DTA curve in figure 7. The curve depicts the thermal stability of a coating during 500 – 690 °C.

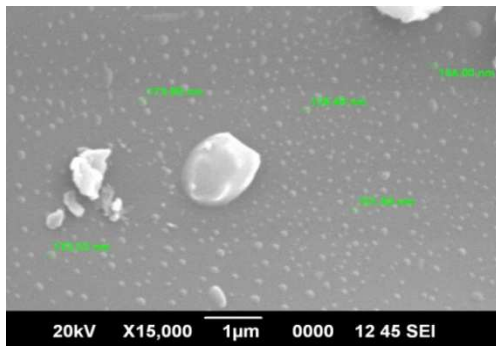


Figure 4: SEM Image of Cu Extracted from Copper Sulphate

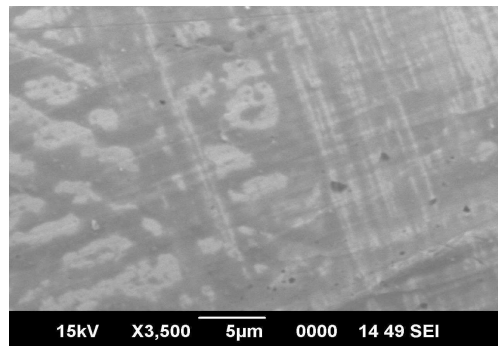


Figure 5: Represents Surface Topography of the Alloy

The process of alloying in a furnace that resembles an ancient one is shown in figure 2 and the construction of the same follows ancient line of thought. The corresponding frequency response in cantilever setup is shown in the figure 3 exhibiting a natural frequency of 439.45 Hz. The SEM image represents the topography of the alloy which is shown in the figure 5 and an average shear load of 3.2373 was exhibited by the strip in a tensometer and its hardness found to be 10HRC (Rockwell hardness). The stress strain analysis of the alloy is shown in the figure 8 and for the triplet sample the max load observed was 2.48 KN with max stress of 698 Mpa and Youngs Modulus of 130680 Mpa. It can be said that such alloys can be used as biometals in dentistry and also in MEMs technology.

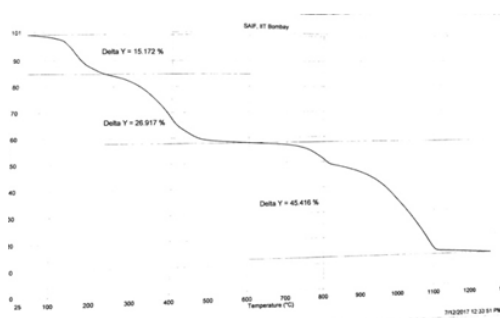


Figure 6: TGA Curve of the Crucible

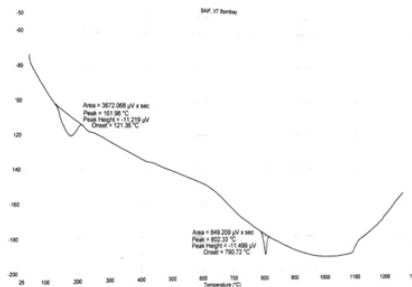


Figure 7: Corresponding DTA Curve

CONCLUSIONS

Reverse Engineering is one of the highly patented and most promising problems solving tool available to engineers. This work has reverse engineered AU-CU-Zn alloy incorporating part whole schema and successive dissection approaches. The synthesized alloy has undergone into SEM, Mechanical and Dynamic characterization to explore the possibilities of its applications. Application of reverse engineering to a entirely new ancient dimension is the novelty of this work. Despite of the fact that Indian Alchemy is always surrounded by myths and fantasies we strongly believe that it has some in depth discernable patterns, which if systematically reverse engineered and explored may serve humanity in an

endless way.

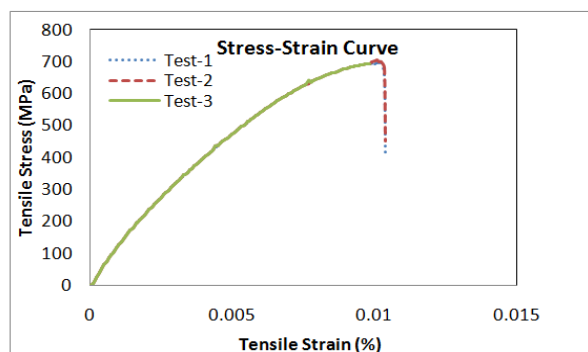


Figure 8: Showing Stress Strain Curve of Synthesized Alloy

ACKNOWLEDGEMENT

The author expresses sincere thanks to the staff and management of GPR Engineering College, Kurnool, AP, India and SAIF, Cochin for their valuable support, assistance and encouragement during this work.

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